



COMPUTER CENTRE BULLETIN

*Vol. 5 Nos 8 & 9
4 September 1972*

*Editor:
Sarah Barry*

ADDITIONAL CORE MEMORY FOR THE PDP-10

In its submission to the Australian Universities Commission for capital funds for computing, the University nominated additional core storage as the item of highest priority.

In anticipation of support from the AUC, and to ensure the earliest possible installation should funds become available early in 1973, the Centre has placed a Letter of Intent for the purchase of 64K words of 650 nsec core memory. Although confirmation or otherwise of this intention will be known by 30 September, we are advising clients of this intention now as the likely installation of significantly more core may affect clients' forward planning.

One outcome would be improved terminal response and batch turn around times. At the moment the PDP-10 is running at its limit of 24 active jobs for the greater part of its time. The main advantage of more core will be that more jobs will reside in core, thereby reducing swapping overheads.

It will also be possible to increase the user's core limit, but if this were increased substantially, the number of core resident jobs would decrease and swapping overheads would again increase. For this reason, should the memory be installed, the maximum likely increase in the user's core limit will only be to 32K.

DATA PREPARATION WORK

With the recent reorganization of the Computer Centre's Secretary's office, many users are confused as to where data preparation work is to be handed in or collected. All data preparation work should be collected from, or handed into, the Receipt/Dispatch window in the foyer of the Centre, not at the Enquiries window. Data preparation forms are available in the Clients' room.

PDP-10 FORTRAN

[WN-95]

1 DEFINITION OF ARITHMETIC STATEMENT FUNCTIONS

The Computer Centre FORTRAN manual MNT-5 does not state that the definition of arithmetic statement functions should precede the first executable statement in the program. This omission will be corrected with the next revision of the manual.

[WN-96]

2 DO LOOPS

The present version of the compiler does not create proper code when a function is used as one of a DO loop's indices.

example:

```
DO 2830 J=1,MINW(6,NN)
```

```
-  
-  
-
```

No diagnostic message is produced during compilation but an improper relocatable binary file is produced, and during loading the message

***ILL. FORMAT BLOCK TYPE NNN PROG.name1 FILE name2/REL

will be produced. This error has been remedied in a later version of the compiler but until this version is adopted, this construction should be avoided.

3 UNARY MINUSES

Use of the unary minuses in logical expressions or mixed logical and arithmetic expressions do not always produce the correct results, for example,

```
J=(J1.AND."777).OR.((-N+1)).AND."777000)  
J=(J1.AND."777)+((-N+1)).AND."777000)
```

This has been corrected in a later version of the compiler which will be implemented in due course. Until it is available, it is suggested that this construction should not be used and that the expression be split into two as;

```
JJ=-N+1  
J=(J1.AND."777).OR.(JJ.AND."777000)
```

PDPUN

[WN-99]

PDPUN may not correctly punch the identification code of other than the first of a series of Fortran files with supplied identification.

This problem will be corrected in the near future.

ALGOL V2

[WN-94]

Version 2 of the Algol system does not allow the use of external FORTRAN subprograms. This feature is discussed in various manuals, and information from Digital indicates that this facility will be available with version 3.

COBOL V3 ERROR

[WN-94]

In use of the sort features of Cobol, it appears that under some circumstances wrong code is created by a Return statement of the form

RETURN filename INTO identifier . . .

This can be overcome by omitting the INTO option, but achieving the same effect by moving the data to the required destination after the Return.

OUTSTANDING PROBLEMS IN COBOL V3

[WN-96]

The following note, prepared on 3 July 1972, gives a summary of known problem areas with Cobol. The large majority of these are corrected by patches issued by Digital and these will be

incorporated as effort becomes available.

THE COBOL COMPILER

- (a) This version does not allow qualification of condition names (to be corrected with version 3A).
- (b) "RETURN name1 INTO name2" as part of a sort does not work (patch exists).
- (c) Comparison for equality of 6-character display-6 fields may not give correct results (patch exists).
- (d) Some external references from non-resident segments are not set up properly. The reported situations were
SORT verb in resident code
RETURN and/or RELEASE in non-resident
TALLY in examine generator
TODAY in the USING generator
Size error and display of a COMP-1 variable
(patches exist).
- (e) "MULTIPLY name1 BY fraction GIVING name2" where fraction is less than 1.0, e.g. 0.0125; will return the value zero to name2 in some circumstances, depending on the typing of name1 and name2 (patch exists).
- (f) A numeric literal in a "VALUE OF DATE WRITTEN" clause fails (patch exists).
- (g) The compiler allows a quoted literal for a PROGRAM-ID, but if the literal is less than 6 characters, the remainder of the name is random (patch exists).
- (h) The compiler does not successfully restart after a catastrophe dump if it was using a command file.
- (i) The compiler will not accept lower case for the first character of a reserved word, although lower case characters are satisfactory in all other positions (a patch to allow the first character to be lower case exists).
- (j) Under some circumstances, a spurious warning message "REDEFINITION NOT THE SAME SIZE AS REDEFINED ITEM" may be given. This can occur when the two fields occupy an integral number of words (patch exists).
- (k) Under some circumstances, Cobol compiler tables are not expanded correctly. This error may manifest itself as compilation or execution error for which no simple

explanation may be found. A patch exists for one situation such as this, but at least one other may exist.

- (l) "PARITY IS EVEN" does not compile properly (patch exists).
- (m) Improper line numbers are given for the procedure division map (patch exists).
- (n) Compilation using the /P switch will produce a catastrophe dump if "TRACE ON/OFF" is used (patch exists).
- (o) It appears as if the construction "OCCURS n1 TO n2 TIMES DEPENDING ON name1" will not create an output record of the size specified by name1 but rather the maximum size n2.

2 THE COBOL EXECUTION PACKAGE - LIBOL

- (a) When a random file is opened for output only, any attempt to write to it will terminate the run with an error message "IT IS ILLEGAL TO CHANGE THE RECORD SIZE WHEN THE ACCESS MODE IS RANDOM" (patch exists).
- (b) When a Cobol program attempts to open two files which share the same buffer area, the resultant error message is garbled (patch exists).
- (c) When an IO file encounters an EOF, a data location is not reset, with the result that the next sequential file input will fail (patch exists).
- (d) Multi-file magnetic tapes are not positioned properly (patch exists).
- (e) Some advisory messages do not conform to the specifications for Digital's 5 series monitors (patch exists).
- (f) IO access to an indexed sixbit file will fail at the first read (patch exists).
- (g) Code created for "USE AFTER ERROR" procedure is incorrect (patch exists).
- (h) File record areas are improperly cleared under some circumstances when adjacent files are opened.
- (i) Some improper checks are made when error situations arise, for example, when a file is not found (some patches exist).
- (j) Under some circumstances the wrong quantity is used to calculate record size when a blocking factor is specified.

This will cause an undeserved error message at execution (patch exists).

- (k) Open immediately after close on magnetic tape fails (patch exists).
- (l) Sort of an indexed file may fail (patch exists).
- (m) Some problems exist with indexed files, e.g. the size of an ASCII key is incorrectly computed and under some circumstances the channel used for the index file is not closed (patch exists).
- (n) Under some circumstances, there may be an interaction between sort and the use of indexed files which will cause the program to fail (patch exists).
- (o) "NEXT GROUP NEXT PAGE" may cause the output of a blank page (patch exists).
- (p) An EOF is found when attempting to read an indexed file sequentially (patch exists).
- (q) A sort which reads a file created by the same program may get an error (patch exists).
- (r) When a null record is found in a random file, subsequent inputs or outputs may fail (patch exists).

3 THE SORT PACKAGE

- (a) Under some circumstances, a command file is not accepted (patch exists).

4 RERUN

Rerun has several problems, some of which are related to the version of the operating system currently being used and it is doubtful if satisfactory results will be achieved. A number of patches exist and when these have been incorporated consideration will be given to further testing.

5 ISAM

The Isam utility has some problems in handling ASCII input files and in conversion from ASCII to sixbit files (patches exist).

6 GENERAL

6.1 Supplement to Digital's Cobol Manual

Attention is drawn to a note in Volume XII no 5 of the DECSYSTEM10 Bulletin which states that a supplement to the Cobol manual is now available. This supplement describes ISAM, COBDDT, and COBOL table handling and is available on request from Digital.

6.2 Factors Affecting the Size of a Compilation

In response to a query regarding the size of the largest program that can be compiled within the present core limits, the following suggestions were offered by Digital.

- (a) Identifiers longer than 6 characters in length require additional storage.
- (b) Condition names (level 88) should be avoided
- (c) Keep paragraph names (number and size) to a minimum
- (d) Do not use values as data items
- (e) Keep literals as short as possible
- (f) Avoid ALTERS
- (g) Do not use the report writer

It is not likely that great advantage can be taken of these suggestions, but it is worth noting that version 3 of Cobol has proved to be able to compile substantially longer source programs than any of its predecessors.

6.3 Recompilation of Existing Programs

A note in the DECSYSTEM10 Bulletin on April 1 1972 indicates the next release of Cobol will retain the existing version of the execution time package for those programs that presently use it. Programs compiled with later versions of Cobol will compile a version of Libol identified by its version number. In this way, existing compiled programs will continue to run without recompilation. It is, however, recommended that programs previously compiled with versions earlier than version 3 be recompiled.

NEW COMMAND DECODER

[WN-95]

A new version of the command decoder (version 2E(36)-3) was implemented on the PDP-10 on Wednesday 12 July. A number of important changes were made with this decoder. The changes documented in section 1 and 2 below, foreshadow the implementation of a general program library and extended command capability.

1 Directories

Library directories on the PDP-10 were renamed and in some cases there was some reorganization of the actual files contained on these areas.

Library directories are referenced by name, e.g. PLOT, STATS, MATRIX. The names are not preceded by a dollar sign; a dollar sign is used to indicate a device or pseudo device, e.g. \$DSK, \$ASR.

User directories are referenced by the project number of the area belonging to that user, e.g. 279, 531.

Files from any directory can be obtained by referencing the directory name and the filename

For example:

- (i) RUN MYPROG PLOT.CALCMP(LIB)
runs the file MYPROG (understood to be on the user's own directory) with the library file CALCMP from the PLOT directory.
- (ii) STATS.BMD02R
executes the program BMD02R on the STATS directory.
- (iii) COPY TUTOR.MYPROG/F4 TO=374.MYPROG/F4
copies the FORTRAN program MYPROG from the TUTOR directory onto project area 374.

On the 12 July, the old library directories (\$BMD, \$MATH, \$MATRIX, \$LEARN, \$PLOT, \$STATS) were removed and reorganized and the new directories are as follows:

<u>Directory</u>	<u>Files</u>	<u>Contents</u>
GAMES	CHES/SAV LOTS/SAV	

ELIZA/SAV
LUNAR/BAS
MOO/SAV
NIM/SAV
QED/SAV

These were all removed from the system directory to GAMES.

HELP	HELP/HLP MANUAL/HLP NEWS/HLP	explains how to use help gives details of current status of computer centre manuals current weekly newsletter
MATH	SSP/REL	a library file containing all the mathematical routines from the scientific subroutine package
MATRIX	MATINV/REL SSP/REL SMIS/SAV	matrix inversion a library file of matrix subroutines from the scientific subroutine package Symbolic Matrix Interpretive System
PLOT	DEC/REL CALCMP/REL DRIVR/SAV FLOCT/SAV FORGN/SAV	old Digital plotter routines basic CalComp software routines program to read cards for CRVPT Flowchart Generation Utility Program Forms Generation Program
STATS	BMD01D/SAV BMD02D/SAV BMD08D/SAV BMD01M/SAV BMD04M/SAV BMD07M/SAV BMD02R/SAV BMD01V/SAV BMD04V/SAV SSP/REL	Simple Data Description Correlation with Transgeneration Cross Tabulation with Variable Stacking Principal Component Analysis Discriminant Analysis for Two Groups Stepwise Discriminant Analysis Stepwise Regression Analysis of Variance for one way Design Analysis of covariance with Multiple Coordinates [Note that these programs are now referenced by their complete names] statistical routines from the scientific subroutines package
TUTOR	MYPROG/F4 MYSUBR/F4	a program and subroutine used in teaching DDT to users

Initial documentation on the library routines will be available in the clients' room, for reference only.

2 Numeric Filenames

filenames can consist of 6 alphanumeric characters. The restriction that the first character had to be alphabetic has been removed. The first character of the processor program name may also be numeric. The editor will presently not recognize all numeric filenames or all numeric processor program names.

3 The DIRECTORY Command

A DIRECTORY command in which no argument is specified assumes a default argument of ALL/ALL. That is

DIR
and DIR ALL/ALL
both list the user's complete directory.

With the implementation of the changes detailed in section 1 and 2 above, the default of ALL/ALL for filename where none is specified, continues to be assumed with the following results.

- | | | |
|-------|-----------------|---|
| (i) | DIR PLOT | lists the directory entry for the file PLOT on the user's area |
| (ii) | DIR PLOT.CALCMP | lists the directory entry for the file CALCMP on the PLOT library |
| (iii) | DIR PLOT. | assumes ALL/ALL for the filename and lists the complete directory of the PLOT library |
| (iv) | DIR 379 | lists the directory entry of the file 379 on the user's area |
| (v) | DIR 379.TEST/F4 | lists the directory entry of the file TEST/F4 on project 379 |
| (vi) | DIR 379. | assumes the default option for filename and lists the directory of project 379 |

4 IDENT Command

The decoder will now recognize the correct spelling of 'exercise' for the argument EXERCISE= exercise-number. EX is an allowable abbreviation for the assignment.

5 ALGOL Command

An ALGOL command, similar to the FORTRAN, COBOL and MACRO commands, has been implemented. The only options available are LIST and NOLIST, BIN and NOBIN.

```
ALGOL(LIST , BIN ) {IN={filename-1 }BIN={filename-2  
NOLIST NOBIN {LST={filename-3
```

6 OVERLAY

An OVERLAY(0) command will now clear any files on the loadlist and commence a new list for the overlay command and those that follow.

7 Error Messages

Decode now gives the correct error messages in all situations.

SCIENTIFIC SUBROUTINE PACKAGE

[WN-98]

The Scientific Subroutine Package comprises a set of over 250 Fortran subroutines covering many areas of mathematics and statistics. The following pages list the name and a very brief description of each of the routines. As indicated, these routines are now available in a number of library files on the PDP-10 system in the following directories.

(a) STATS directory

The library file SSP/REL contains all the statistical routines from the SSP package. Any of these can be loaded with a user's program by a command of the form

```
RUN prog-name STATS.SSP(LIB)
```

(b) MATRIX directory

Again, the library file SSP/REL on the MATRIX directory contains all the matrix routines of the SSP package. Any of these can be loaded with a user's program by a command of the form

RUN prog-name MATRIX.SSP(LIB)

(c) MATH directory

There are three library files of SSP routines on the MATH directory.

- (i) SSPP/REL contains polynomial routines
- (ii) SSPF/REL contains other mathematical functions
- (iii) SSPM/REL contains miscellaneous routines.

The listing of the routines gives the particular library file in which any given routine is to be found.

The user can load a routine from any library with an appropriate RUN command. For example, if a program called routines from both the library files SSPP/REL and SSPM/REL the command would be

RUN prog-name MATH.SSPP(LIB) MATH.SSPM(LIB)

The scientific subroutine package is classified as type 4 software and is therefore made available on an 'as is' basis.

Interim documentation is now available in the clients' room at the Centre for reference only.

CATEGORIAL GUIDE TO SUBROUTINES AND
SAMPLE PROGRAMS

B5-8 & 9
26Aug72

(Subroutines added in Version III are marked with
an asterisk)

STATISTICS

Data Screening in STATS.SSP(LIB) on PDP-10

+	TALLY--totals, means, standard deviations, minimums, and maximums	27
	BOUND--selection of observations within bounds	27
	SUBST--subset selection from observation matrix	28
	ABSNT--detection of missing data	28
	TAB1--tabulation of data (one variable)	29
	TAB2--tabulation of data (two variables)	30
	SUBMX--building of subset matrix	31

Correlation and Regression (See Smoothing,
Factorization) in STATS.SSP(LIB) on PDP-10

	CORRE--means, standard deviations, and correlations	32
	*MISR--means, standard deviations, third and fourth moments, correlations, simple regression coefficients and their standard errors; considers that data may be missing	33
	ORDER--rearrangement of intercorrela- tions	36
	MULTR--multiple linear regression	37
	GDATA--data matrix generation for polynomial regression	39
	*STPRG--stepwise multiple linear regression	41
	*PROBT--probit analysis	44
	CANOR--canonical correlation	47

Design Analysis (See Smoothing, Regression,
Factorization) in STATS.SSP
(LIB) on PDP-10

AVDAT--data storage allocation	49
AVCAL-- Σ and Δ operation	50
MEANQ--mean square operation	57

Discriminant Analysis in STATS.SSP(LIB) on
PDP-10.

DMATX--means and dispersion matrix	52
DISCR--discriminant functions	53

Factor Analysis (See Eigenanalysis) in STATS.
SSP(LIB) on PDP-10

TRACE--cumulative percentage of eigenvalues	55
LOAD--factor loading	56
VARMX--varimax rotation	56

Time Series (See Smoothing) in STATS.SSP
(LIB) on PDP-10.

AUTO--autocovariances	59
CROSS--cross covariances	60
SMO--application of filter coefficients (weights)	61
EXSMO--triple exponential smoothing	62

Nonparametric Statistics in STATS.SSP(LIB)
on PDP-10.

*KOLMO--Kolmogorov-Smirnov one- sample test	63
*KOLM2--Kolmogorov-Smirnov two- sample test	65
*SMIRN--Kolmogorov-Smirnov limiting distribution values	66
CHISQ-- χ^2 test for contingency tables	68
KRANK--Kendall rank correlation	69
*MPAIR--Wilcoxin's signed ranks test	70

+ THIS SUBROUTINE ALSO LOCATED IN MATRIX.SSP(LIB) ON PDP-10.

QTEST--Cochran Q-test	71	RCPY--copy row of matrix into vector	94
RANK--rank observations	71	CCPY--copy column of matrix into vector	95
*SIGNT--sign test	72	DCPY--copy diagonal of matrix into vector	95
SRANK--Spearman rank correlation	73	XCPY--copy submatrix from given matrix	96
TIE--calculation of ties in ranked observations	74	MSTR--storage conversion	96
TWOAV--Friedman two-way analysis of variance statistic	74	LOC--location in compressed-stored matrix	97
UTEST--Mann-Whitney U-test	75	CONVT--single-precision/double-precision conversion	97
WTEST--Kendall coefficient of concordance	76	ARRAY--vector storage/double-dimensioned storage conversion	98
<u>Generation of Random Variates - in STATS. Distribution Functions</u> SSP (LIB) on PDP-10.		<u>Matrices: Operations in MATRIX.SSP (LIB) on PDP-10.</u>	
RANDU--uniform random deviates	77	GMADD--add two general matrices	98
GAUSS--normal deviates	77	GMSUB--subtract two general matrices	99
*NDTR--normal distribution function	78	GMPRD--product of two general matrices	99
*BDTR--beta distribution function	78	GMTRA--transpose of a general matrix	100
*CDTR-- χ^2 distribution function	81	GTPRD--transpose product of two general matrices	100
*NDTRI--inverse of normal distribution function	83	MADD--add two matrices	101
		MSUB--subtract two matrices	101
<u>Elementary Statistics and Miscellany</u> in STATS.SSP (LIB) on PDP-10.		MPRD--matrix product (row into column)	102
MOMEN--first four moments	85	MTRA--transpose a matrix	102
TTEST--test on population means	86	T PRD--transpose product	103
*BISER--biserial correlation coefficient	87	MATA--transpose product of matrix by itself	103
*PHI--phi coefficient	88	SADD--add scalar to matrix	104
*POINT--point-biserial correlation coefficient	89	SSUB--subtract scalar from a matrix	104
*TETRA--tetrachoric correlation coefficient	90	SMPY--matrix multiplied by a scalar	105
*SRATE--survival rates	92	SDIV--matrix divided by a scalar	105
<u>Matrices: Storage</u> in MATRIX.SSP (LIB) on PDP-10.		SCLA--matrix clear and add scalar	106
MCPY--matrix copy	94	DCLA--replace diagonal with scalar	106

RADD--add row of one matrix to row of another matrix	107	*RSLMC--solution of simultaneous linear equations with iterative refinement	124
CADD--add column of one matrix to column of another matrix	107	*FACTR--triangular factorization of a nonsingular matrix	126
SRMA--scalar multiply row and add to another row	108	MFGR, DMFGR--matrix factorization and rank determination	127
SCMA--scalar multiply column and add to another column	108	GELS, DGELS--system of general simultaneous linear equations with symmetric coefficients	133
RINT--interchange two rows	109	GELB, DGELB--system of general simultaneous linear equations with band-structured coefficients	137
CINT--interchange two columns	109	*MTDS, DMTDS--divide a matrix by a triangular matrix	142
RSUM--sum the rows of a matrix	110	*MLSS, DMLSS--solution of simultaneous linear equations with symmetric positive semidefinite matrix	145
CSUM--sum the columns of a matrix	110	*MCHB, DMCHB--triangular factorization of a symmetric positive definite band matrix	148
RTAB--tabulate the rows of a matrix	111	*MFSS, DMFSS--triangular factorization and rank determination of a symmetric positive semidefinite matrix	152
CTAB--tabulate the columns of a matrix	112	*MFSD, DMFSD--triangular factorization of a symmetric positive definite matrix	158
RSRT--sort matrix rows	112	LLSQ, DLLSQ--solution of linear least-squares problems	160
CSRT--sort matrix columns	113		
RCUT--partition by row	113		
CCUT--partition by column	114		
RTIE--adjoin two matrices by row	114		
CTIE--adjoin two matrices by column	115		
*MPRC, DMPRC--permute rows or columns	115		
MFUN--matrix transformation by a function	117		
RECP--reciprocal function for MFUN	117		
<u>Matrices: Inversion, Systems of Linear Equations and Related Topics</u> in MATRIX.SSP(LIB) on PDP-10.		<u>Matrices: Eigenanalysis and Related Topics</u> in MATRIX.SSP(LIB) on PDP-10.	
+ MINV--matrix inversion	118	+ EIGEN--eigenvalues and eigenvectors of a real, symmetric matrix	164
*SINV, DSINV--invert a symmetric positive definite matrix	119	+ NROOT--eigenvalues and eigenvectors of a special nonsymmetric matrix	166
SIMQ--solution of simultaneous linear, algebraic equations	120	*ATEIG--eigenvalues of a real almost triangular matrix	167
++ GELG, DGELG--system of general simultaneous linear equations by Gauss elimination	121	*HSBG--reduction of a real matrix to almost triangular form	169
+ ALSO IN STATS.SSP(LIB) on PDP-10			
++ ALSO IN MATH.SSPM(LIB) on PDP-10			

<u>Polynomials: Operations</u> in MATH. SSPP(LIB) on PDP-10.		*PRBM, DPRBM--roots of a real poly- nomial by Bairstow's algorithm	189
PADD--add two polynomials	171		
PSUB--subtract one polynomial from another	171	*PQFB, DPQFB--determine a quadratic factor of a real poly- nomial	193
PMPY--multiply two polynomials	172		
PDIV--divide one polynomial by another	172	<u>Polynomials: Special Types</u> in MATH. SSPP(LIB) on PDP-10.	
PCLA--replace one polynomial by another	173	++ CNP, DCNP--value of N th Chebyshev polynomial	198
PADDM--multiply polynomial by constant and add to another polynomial	173	++ CNPS, DCNPS--value of series expansion in Chebyshev polynomials	199
PVAL--value of a polynomial	174	TCNP, DTCNP--transform series expansion in Chebyshev polynomials to a polynomial	200
PVSUB--substitute variable of polynomial by another polynomial	174	CSP, DCSP--value of N th shifted Chebyshev polynomial	201
PILD--evaluate polynomial and its first derivative	175	CSPS, DCSPS--value of series expansion in shifted Chebyshev poly- nomials	202
PDER--derivative of a polynomial	175	TCSP, DTCSP--transform series expansion in shifted Chebyshev poly- nomials to a polynomial	203
PINT--integral of a polynomial	176	HEP, DHEP--value of Hermite polynomial	205
PQSD--quadratic synthetic division of a polynomial	176	HEPS, DHEPS--value of series expansion in Hermite polynomials	206
PCLD--complete linear synthetic division	177	THEP, DTHEP--transform series expan- sion in Hermite polynomials to a polynomial	207
PGCD--greatest common divisor of two polynomials	177	LAP, DLAP--value of Laguerre polynomial	208
PNORM--normalize coefficient vector of polynomial	178	LAPS, DLAPS--value of series expansion in Laguerre polynomials	209
PECN, DPECN--economization of a poly- nomial for symmetric range	178	TLAP, DTLAP--transform series expan- sion in Laguerre poly- nomials to a polynomial	210
PECS, DPECS--economization of a poly- nomial for unsymmetric range	180	LEP, DLEP--value of Legendre polynomial	212
		LEPS, DLEPS--value of series expansion in Legendre polynomials	213
<u>Polynomials: Roots</u> in MATH. SSPM(LIB) on PDP-10			
+ POLRT--real and complex roots of a real polynomial	181		
PRQD, DPRQD--roots of a real polynomial by QD algorithm with dis- placement	183		

+ ALSO IN STATS.SSP(LIB) on PDP-10
++ THIS SUBROUTINE in MATH. SSPM(LIB) on PDP-10.

TLEP, DTLEP--transform a series expansion in Legendre polynomials to a polynomial	214	ATSE, DATSE--table selection out of an equidistant table	251
<u>Roots of Nonlinear Equations</u> in MATH. SSPM(LIB) on PDP-10.		*SG13, DSG13--local least-squares smoothing of tabulated functions	253
RTWI, DRTWI--refine estimate of root by Wegstein's iteration	215	*SE13, DSE13	
RTMI, DRTMI--determine root within a range by Mueller's iteration	217	*SE15, DSE15	
RTNI, DRTNI--refine estimate of root by Newton's iteration	220	*SE35, DSE35--local least-squares smoothing of equidistantly tabulated functions	255
<u>Extremum of Functions</u> in MATH. SSPM(LIB) on PDP-10		*APFS, DAPFS--solve normal equations for least-squares fit	260
FMFP, DFMFP--unconstrained minimum of a function of several variables--Davidon method	221	*APCH, DAPCH--least-squares polynomial approximation	263
FMCG, DFMCG--unconstrained minimum of a function of several variables--conjugate gradient method	225	*ARAT, DARAT	
<u>Permutations</u> in MATH. SSPM(LIB) on PDP-10.		*FRAT, DFRAT--rational least-squares approximation	265
*PPRCN--composition of permutations	231	*APLL, DAPLL--linear least-squares approximation	271
*PERM--operations with permutations and transpositions	232	FORIF--Fourier analysis of a given function	274
<u>Sequences: Sums and Limits</u> in MATH. SSPM(LIB) on PDP-10.		FORIT--Fourier analysis of a tabulated function	275
TEAS, DTEAS--limit of a given sequence	234	HARM, DHARM--complex three-dimensional Fourier analysis	276
TEUL, DTEUL--sum of a given function sequence	238	RHARM, DRHARM--real one-dimensional Fourier analysis	281
<u>Interpolation, Approximation, and Smoothing</u> in MATH. SSPM(LIB) on PDP-10.		*APMM, --linear Chebyshev approximation over a discrete range	283
ALI, DALI--Aitken-Lagrange interpolation	241	<u>Numerical Quadrature</u> in MATH. SSPF(LIB) on PDP-10.	
AHI, DAHI--Aitken-Hermite interpolation	243	QTFG, DQTFG--integration of monotonically tabulated function by trapezoidal rule	289
ACFI, DACFI--continued fraction interpolation	245	QTFE, DQTFE--integration of equidistantly tabulated function by trapezoidal rule	290
ATSG, DATSG--table selection out of a general table	248	QSF, DQSF--integration of equidistantly tabulated function by Simpson's rule	291
ATSM, DATSM--table selection out of a monotonic table	250	QHFG, DQHFG--integration of monotonically tabulated function with first derivative by Hermitian formula of first order	293

26Aug72

QHFE, DQHFE--integration of equidistantly tabulated function with first derivative by Hermitian formula of first order 294

QHSG, DQHSG--integration of monotonically tabulated function with first and second derivatives by Hermitian formula of first order 295

QHSE, DQHSE--integration of equidistantly tabulated function with first and second derivatives by Hermitian formula of second order 296

QATR, DQATR--integration of a given function by trapezoidal rule together with Romberg's extrapolation method 297

QG2-QG10, DQG4-DQG32--integration of a given function by Gaussian quadrature formulas 299

QL2-QL10, DQL4-DQL32--integration of a given function by Gaussian-Laguerre quadrature formulas 303

QH2-QH10, DQH8-DQH64--integration of a given function by Gaussian-Hermite quadrature formulas 308

QA2-QA10, DQA4-DQA32--integration of a given function by associated Gaussian-Laguerre quadrature formulas 314

Numerical Differentiation in MATH. SSPF(LIB)

on PDP-10

*DGT3, DDGT3--differentiation of a tabulated function by parabolic interpolation 319

*DET3, DDET3

*DET5, DDET5--differentiation of an equidistantly tabulated function 320

*DCAR, DDCAR--derivative of a function at the center of an interval 324

*DBAR, DDBAR--derivative of a function at the border of an interval 327

Ordinary Differential Equations in MATH. SSPF(LIB) on PDP-10.

RK1--solution of first-order differential equation by Runge-Kutta method 331

RK2--tabulated solution of first-order differential equation by Runge-Kutta method 332

RKGS, DRKGS--solution of system of first-order ordinary differential equations with given initial values by the Runge-Kutta method 333

HPCG, DHPG--solution of general system of first-order ordinary differential equations with given initial values by Hamming's modified predictor-corrector method 337

HPCL, DHPCL--solution of linear system of first-order ordinary differential equations with given initial values by Hamming's modified predictor-corrector method 343

+
LBVP, DLBVP--solution of system of linear first-order ordinary differential equations with linear boundary conditions by method of adjoint equations 350

Special Functions in MATH. SSPF(LIB) on PDP-10.

GMMMA--gamma function 361

++ *DLGAM--log of gamma function 362

BESJ--J Bessel function 363

EXPI--exponential integral	368
SICI--sine cosine integral	370
CS--Fresnel integrals	372
CEL1, DCEL1--complete elliptic integral of the first kind	374
CEL2, DCEL2--complete elliptic integral of the second kind	376
ELI1, DELI1--generalized elliptic integral of the first kind	378
ELI2, DELI2--generalized elliptic integral of the second kind	380
JELF, DJELF--Jacobian elliptic functions	382

B5-8 & 9
26Aug72